CLASSIFICATION OF KARST DRAINAGE BASINS

The interpretation of groundwater tracer data to delineate coherent drainage networks can be substantially aided by a conceptual classification of karst basins (Ray and Currens, 1996). This classification centers on the dominant recharge component that controls the development and configuration of trunk flow within a basin and is derived from assessing hundreds of karst basins mapped in Kentucky. The following scenario describes fluvial networks encountering highly soluble rocks in a simple evolutionary sequence (Ray, 1999, 2001).

A conduit flow route may initially develop when a fluvial system begins to incise soluble rocks. Flow along secondary bedrock porosity evolves and a subsurface conduit such as a meander cutoff route or a valley-paralleling conduit forms an incipient groundwater basin. In these initial cases most of the returning spring-flow is derived from the nearby stream sink or losing reach. The capacity of this initial groundwater route may be less than the stream's low flow or equivalent to base or moderate flow volumes. Consequently, higher flows continue to erode the prevailing surface channel. Basins containing losing streams that maintain viable surface overflow channels across the watershed are termed *Overflow Allogenic* or *Type I* basins (illustration "*a*" in Figure 25). Boiling, Mill Stream, Brelsford and River Bend spring basins are examples of Overflow Allogenic basins (Allogenic flow is defined as non-local stream drainage from either insoluble or soluble rock terrane). Also, substantial portions of Head of Wolf Creek and King spring basins contain surface overflows.

When the capacity of a trunk conduit evolves to the point that all ranges of allogenic flow are channeled underground, the surface stream is beheaded, thus creating a blind valley at the margin of an abandoned karst valley or sinkhole plain. An *Underflow Allogenic* or *Type II* basin (illustration "*b*" in Figure 25) results when allogenic overflow routes are no longer maintained across a karst basin. Cook, Walton and Wright spring basins are examples of Underflow Allogenic basins. Both basin types I and II can be considered *influent or fluviokarst* drainage systems (White, 1988).

These karst-basin types not only reflect a reasonable evolutionary sequence but also may help to explain flood response and water quality of some resurgent springs (Worthington and others, 1992). Suspended sediment and contaminants mobilized during flooding may partially bypass springs draining Type I basins. This overflow-route bypass is not available in Type II basins where springs drain the entire karst watershed. A similar classification was developed by Jones (1997) where *open* karst basins maintain through-flowing surface drainage networks, whereas *closed* basins do not.

A third type of karst watershed lacks significant allogenic recharge and is termed a *Local Autogenic* or *Type III* basin (illustration "*c*" in Figure 25). These typically smaller basins are primarily recharged by infiltration of precipitation through the land surface and internal runoff into sinkholes. They are commonly located on the margins of stream-less karst plateaus. Barkers Mill, French Creek and Buttermilk Falls spring basins are examples of primarily autogenic recharge basins.

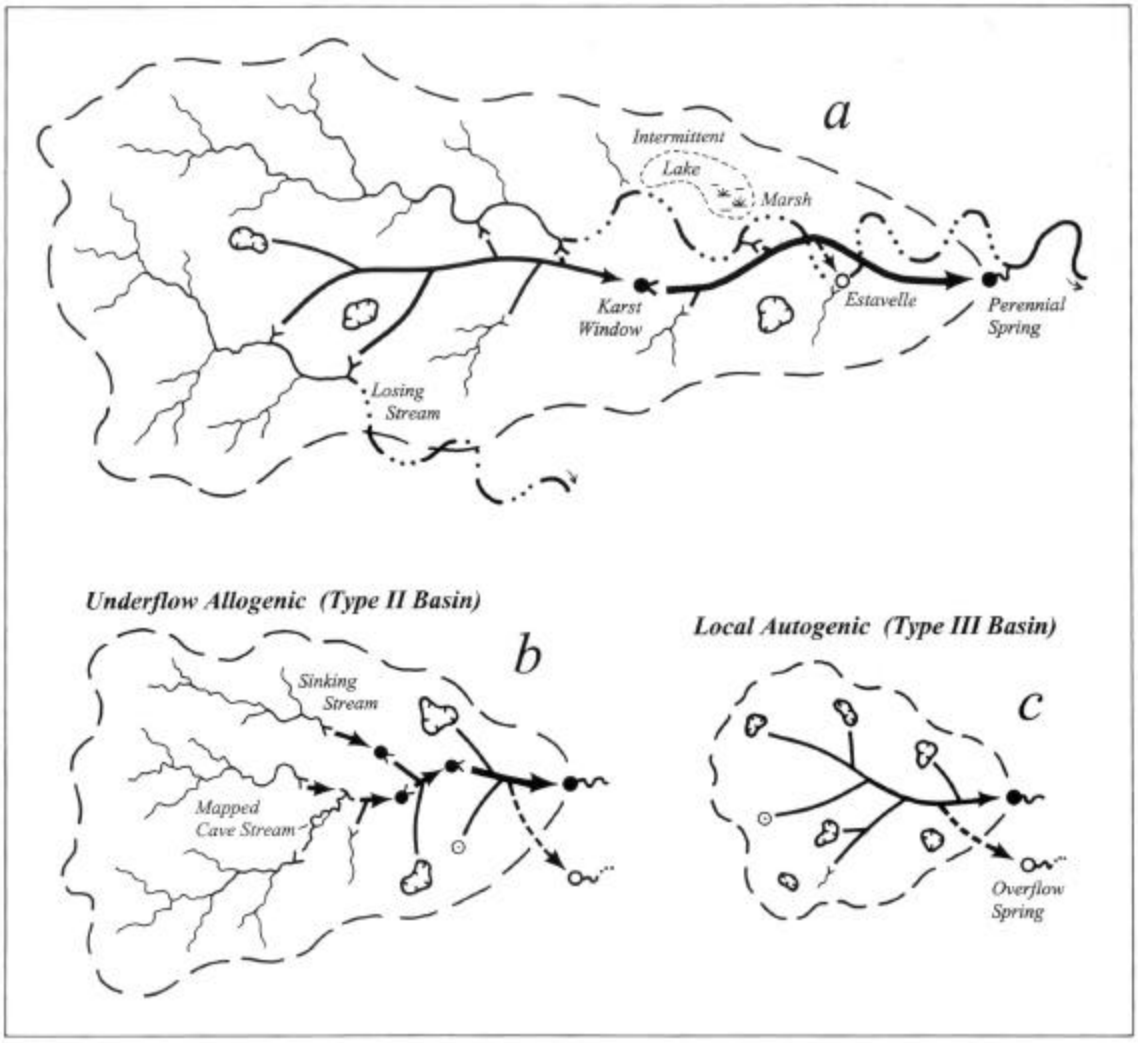

Figure 25: Major Types of Karst Drainage Basins

INTERPRETATION OF RESULTS

DISTRIBUTION OF PRIMARY LAND COVER

Land cover data were acquired from the National Land Cover Data Set for the conterminous United States, developed by the US Geological Survey (Vogelmann and others, 2001). Compilers used satellite data and a variety of additional information including topography, census, agricultural statistics, soil characteristics, other land cover maps, and wetlands data to determine land cover at a 30 m (100 ft) resolution. Twenty-one classes of land cover were identified. Fifteen classes appear in Kentucky. A subsequent accuracy assessment indicated that the coverage was 66% accurate. Figure 26 shows a simplified land-cover map of Kentucky. The dense agricultural activity in the SW area is indicated by the buff color, whereas a mixture of agricultural and forested land in the NE area is shown by mixed green and buff colors.

For this study, Primary Land Cover includes any type with as much as 3 % cover in any of the studied groundwater basins. These primary types include *Row Crop, Pasture and Hay, Deciduous Forest, Mixed Forest and Woody Wetland*.

Row Crops

In the SW study area, *Row Crops* averaged 38.6% of the total land area, ranging from a high of 47.1% (Walton) to a low of 13.2% (Brelsford). This represents a total of 17,617 ha (43,530 ac; 68.0 mi^2; 176.1 km^2)

The NE study area had less row-crop area, with an average of 21.6%, ranging from a high of 9.3% (Boiling) to a low of 15.2% (Head of Wolf). This represents a total of 11,784 ha (29,119 ac; 45.5 mi^2; 117.8 km^2).

Pasture & Hay

In the SW study area, *Pasture and Hay* averaged 42.3%, ranging from a high of 52.2% (Brelsford) to a low of 30.3% (Walton). This represents a total of 18,367 ha (45,385 ac; 70.9 mi^2; 183.6 km^2).

In the NE study area, *Pasture and Hay* averaged 22.3%, ranging from a high of 43.9% (French Creek) to a low of 9.1% (Buttermilk Falls). This represents a total of 10,727 ha (26,505 ac; 41.4 mi^2; 107.3 km^2).

Deciduous Forest

In the NE study area, *Deciduous Forest* averaged 48.4% of the total land area, ranging from a high of 66.8% (Head of Wolf) to a low of 27.2% (French Creek). This represents a total of 18,259 ha (45,118 ac; 70.5 mi^2; 182.6 km^2).

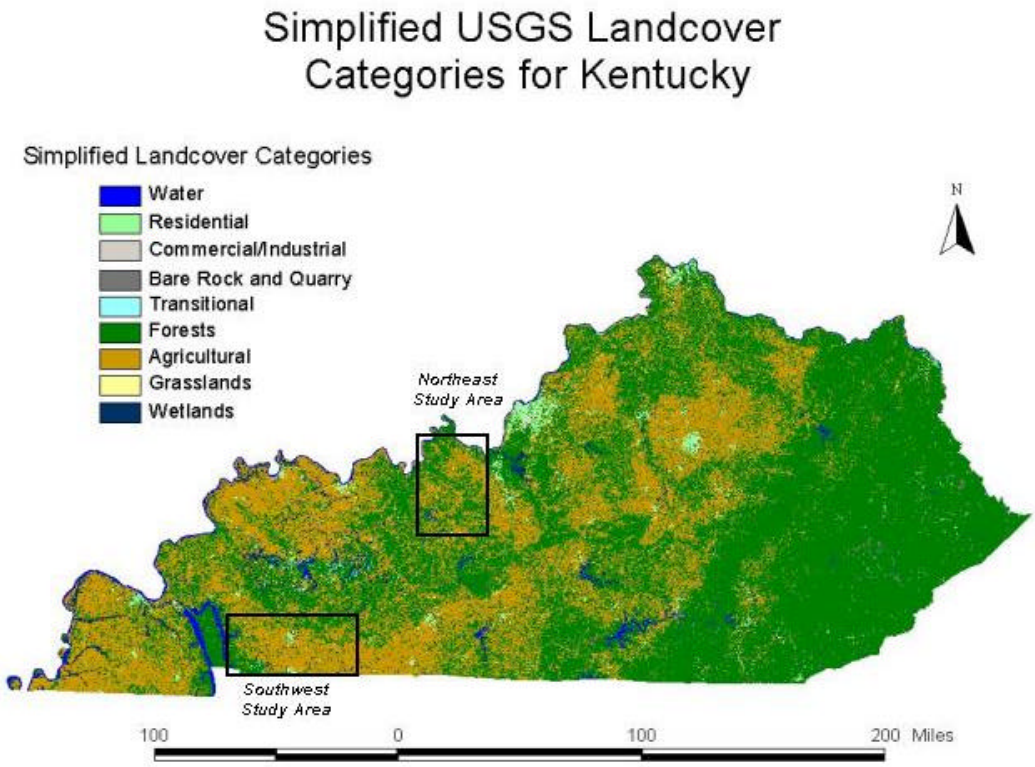

Figure 26: Simplified Land-Cover Map of Kentucky

In the SW study area, *Deciduous Forest* averaged only 11.7% of the total land area, ranging from a high of 26% (Brelsford) to a low of 3% (Barkers Mill). This represents a total of 6,302 ha (15,573 ac; 24.3 mi^2; 62.9 km^2).

Mixed Forest and Woody Wetlands

The remaining two categories with 3% or greater total basin area were *Mixed Forest* and *Woody Wetlands*. In the NE area, Boiling, Head of Wolf and Buttermilk Falls contained 5.4, 3.3, and 5.8%, respectively, of *Mixed Forest*. Only Brelsford, in the SW area, contained a significant amount of *Mixed Forest* at 5.1%.

Percentages of primary land cover in each basin are shown in Table 3. Figures 27-38 illustrate the land cover in the vicinity of individual groundwater basins, which are identified by the main spring and a green dashed groundwater-basin boundary.

ID #	Spring Name	Deciduous Forest	Mixed Forest	Pasture and Hay	Row Crop	Woody Wetland	Total
0855	**Boiling**	40.22	5.37	23.44	29.30	-	98.33
1838	**French Creek**	27.16	3.65	43.90	24.03	-	98.73
1824	**Buttermilk Falls**	59.30	5.80	9.06	17.74	-	91.89
1063	**Head of Wolf Creek**	66.81	3.30	12.70	15.23	-	98.03
0859	**Barkers Mill**	3.31	-	49.07	43.23	-	95.61
0860	**River Bend**	4.55	-	42.81	45.39	3.74	96.49
1141	**Cook**	16.20	-	43.87	33.28	-	93.35
1448	**Brelsford**	25.99	5.12	52.20	13.22	-	96.53
0203	**Mill Stream**	22.05	-	34.62	38.97	-	95.64
1489	**King**	7.42	-	38.25	46.80	4.22	96.69
1457	**Walton**	8.04	-	30.03	46.03	12.27	96.38
1475	**Wright**	6.17	-	47.53	42.16	-	95.86

Table 3: Percentages of Primary Land Cover in each Basin (> 3%)

Secondary Land-Cover Types

Additional minor land-cover types amounting to less than 3% of basin area are commonly visible on these maps and are included in the legend as Secondary Land Cover. These types include *Urban/Residential, Recreational Grasslands, Water, Limestone Quarry, Evergreen Forest, Emergent Herbaceous Wetlands* and *Transitional* (Fort Campbell Military Reservation).

A minor misinterpretation of land cover was noted in Figure 37, showing Walton Spring. The *Woody Wetland* represented in the area around Walton Spring, in the northwestern portion of the basin, is actually *Deciduous Forest*. This terrain is known to be a rugged dissected ravine and therefore cannot contain woody wetland vegetation. Likewise, another ravine network in the northeast portion of Figure 37, lying outside the Walton Spring basin, is misrepresented as woody wetland. Both of these areas have been observed in the field and contain mature deciduous forest. When the land cover for Walton Spring basin is corrected, the *Deciduous Forest* type land cover increases from 7.8% to 8.6% and the *Woody Wetland* decreases from 11.2% to 10.4%.

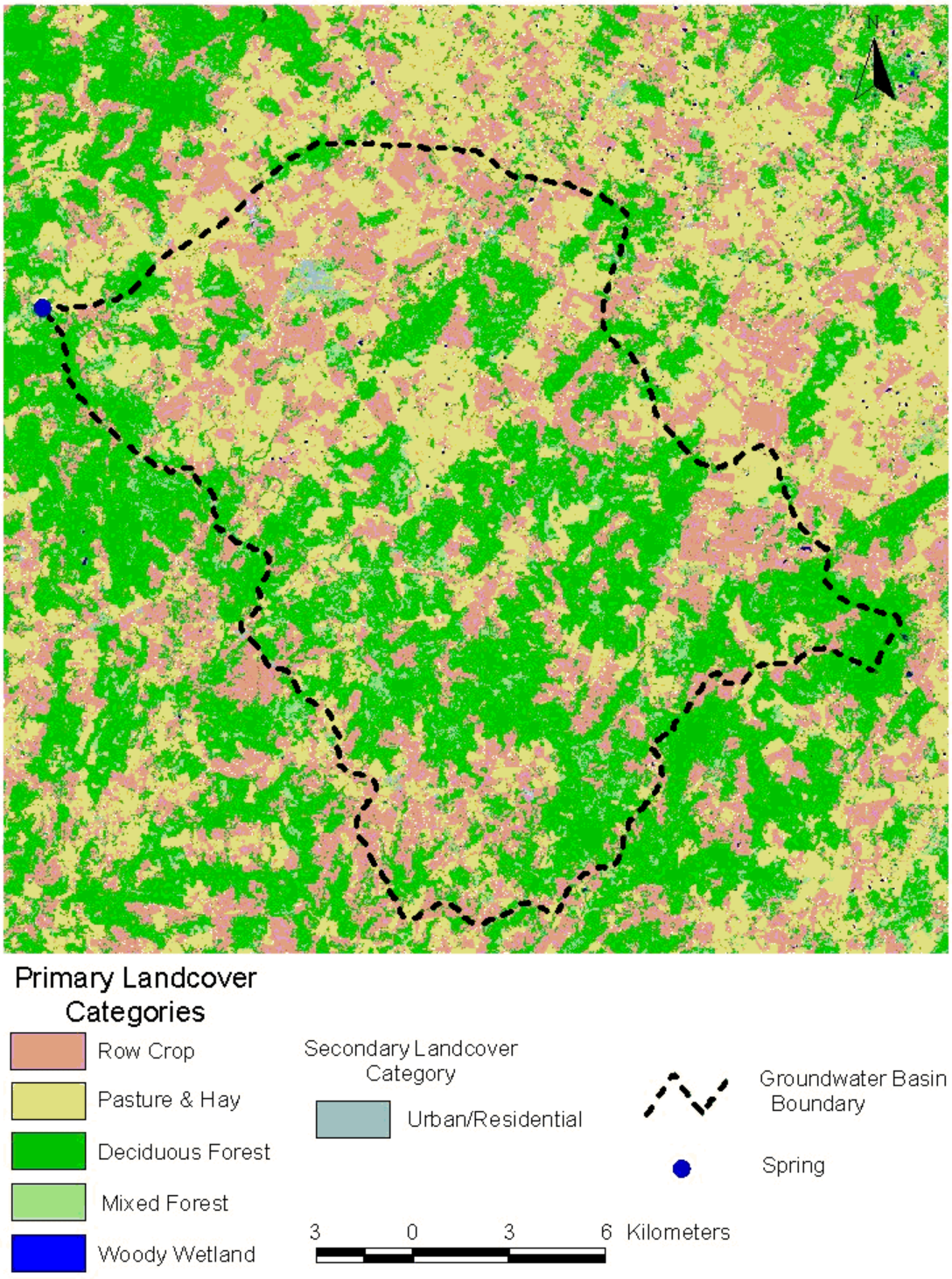

Figure 27: Boiling Springs Basin Land Cover

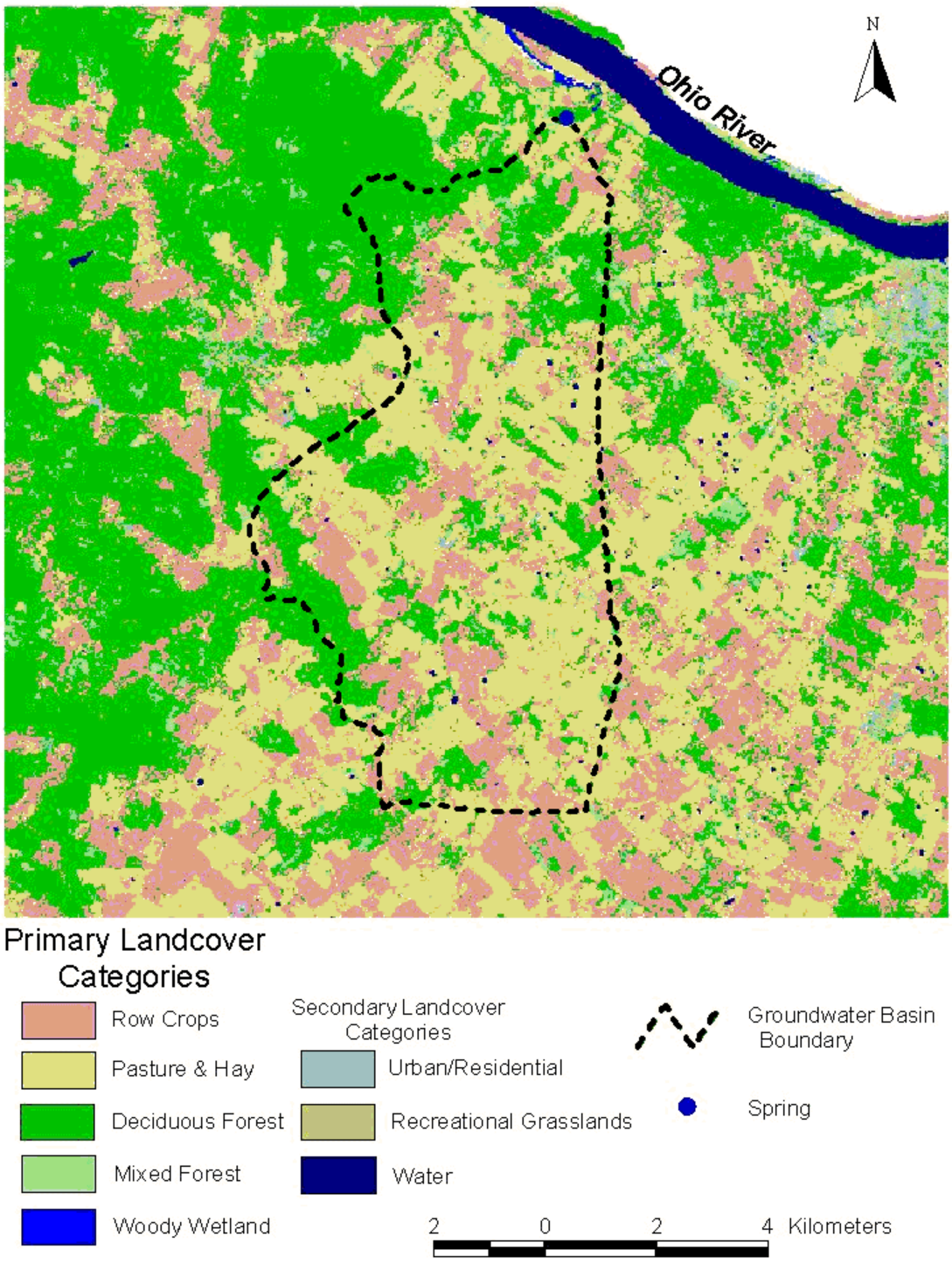

Figure 28: French Creek Springs Basin Land Cover

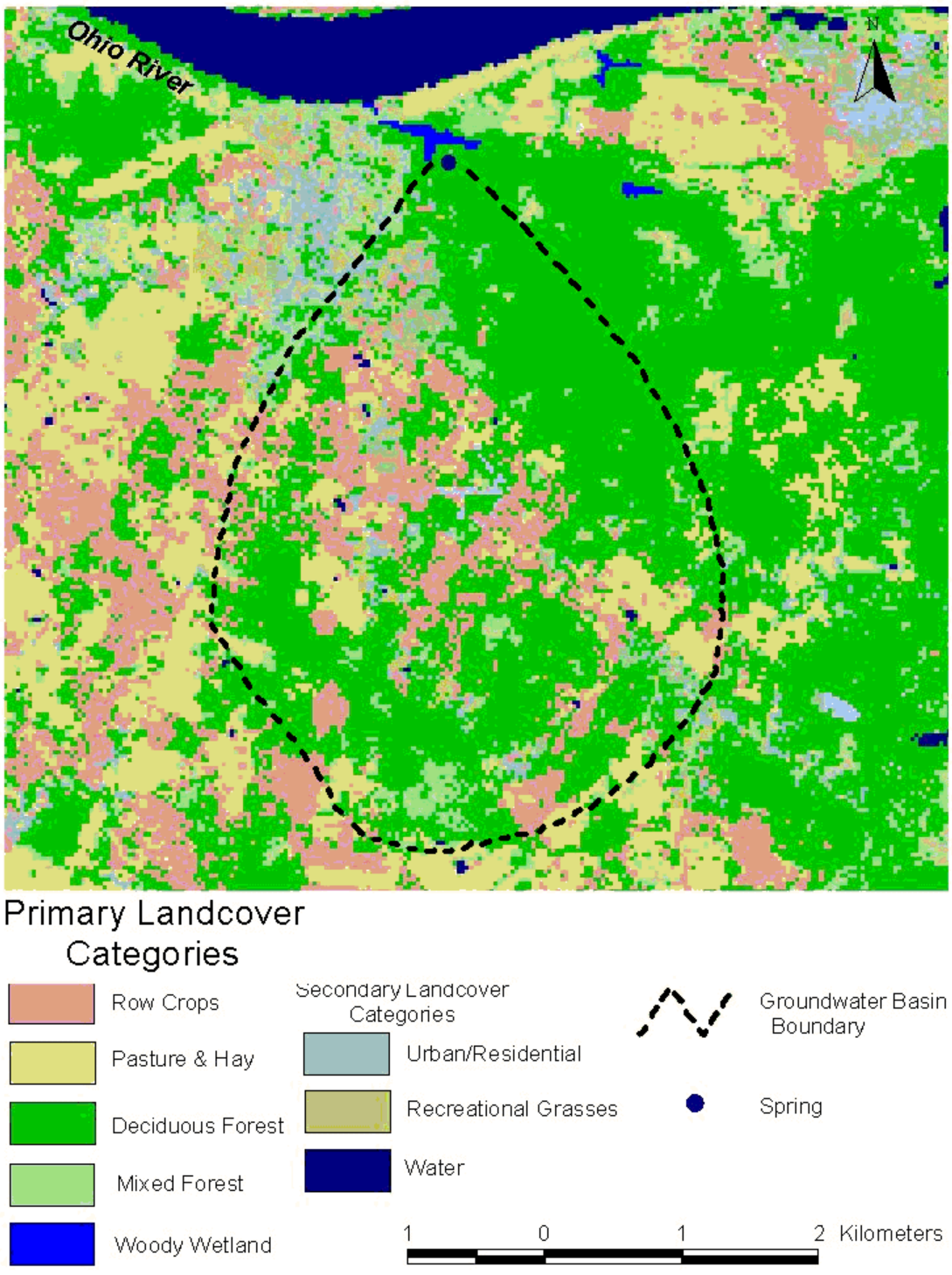

Figure 29: Buttermilk Falls Spring Basin Land Cover

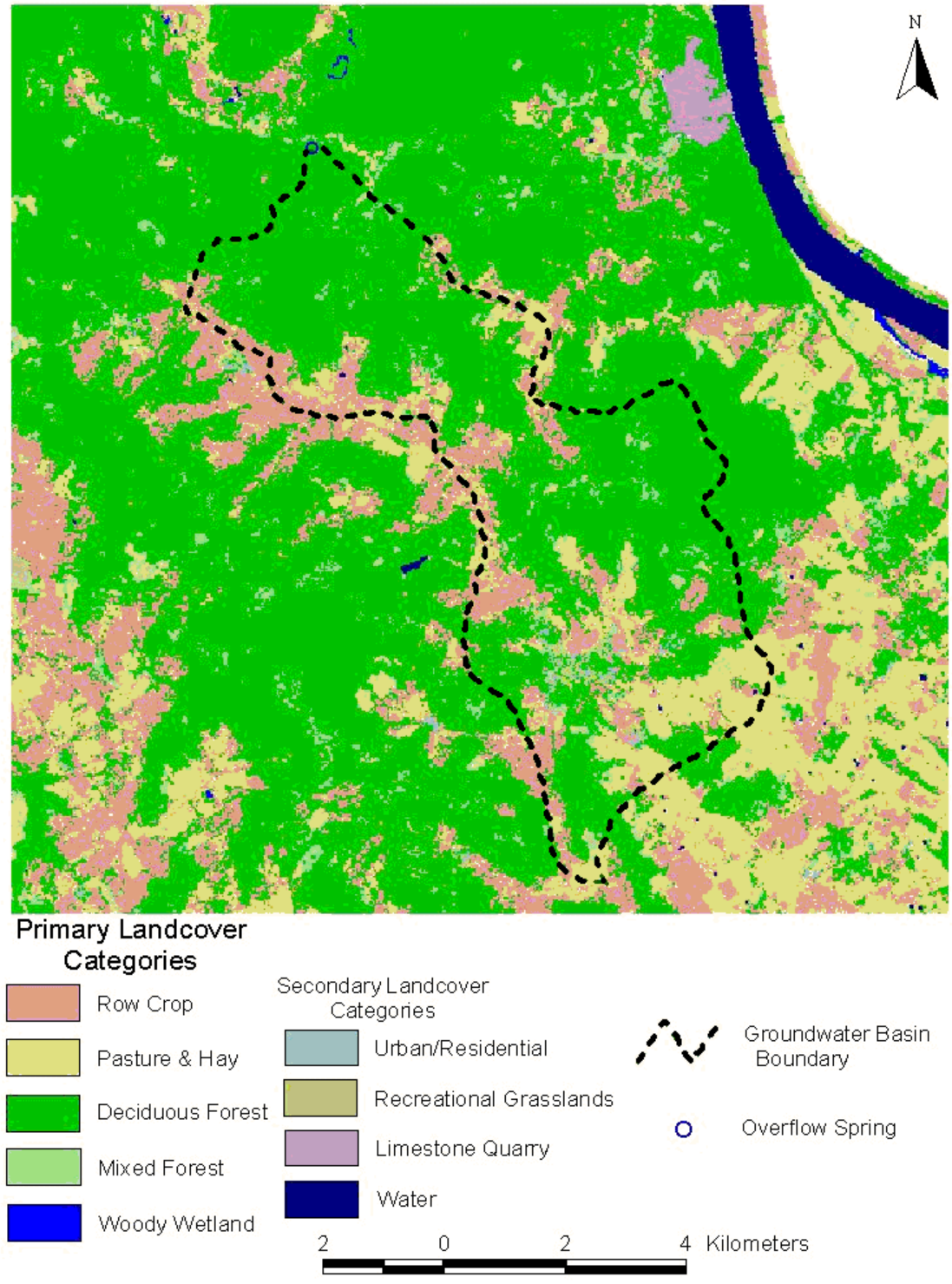

Figure 30: Head of Wolf Creek Spring Basin Land Cover

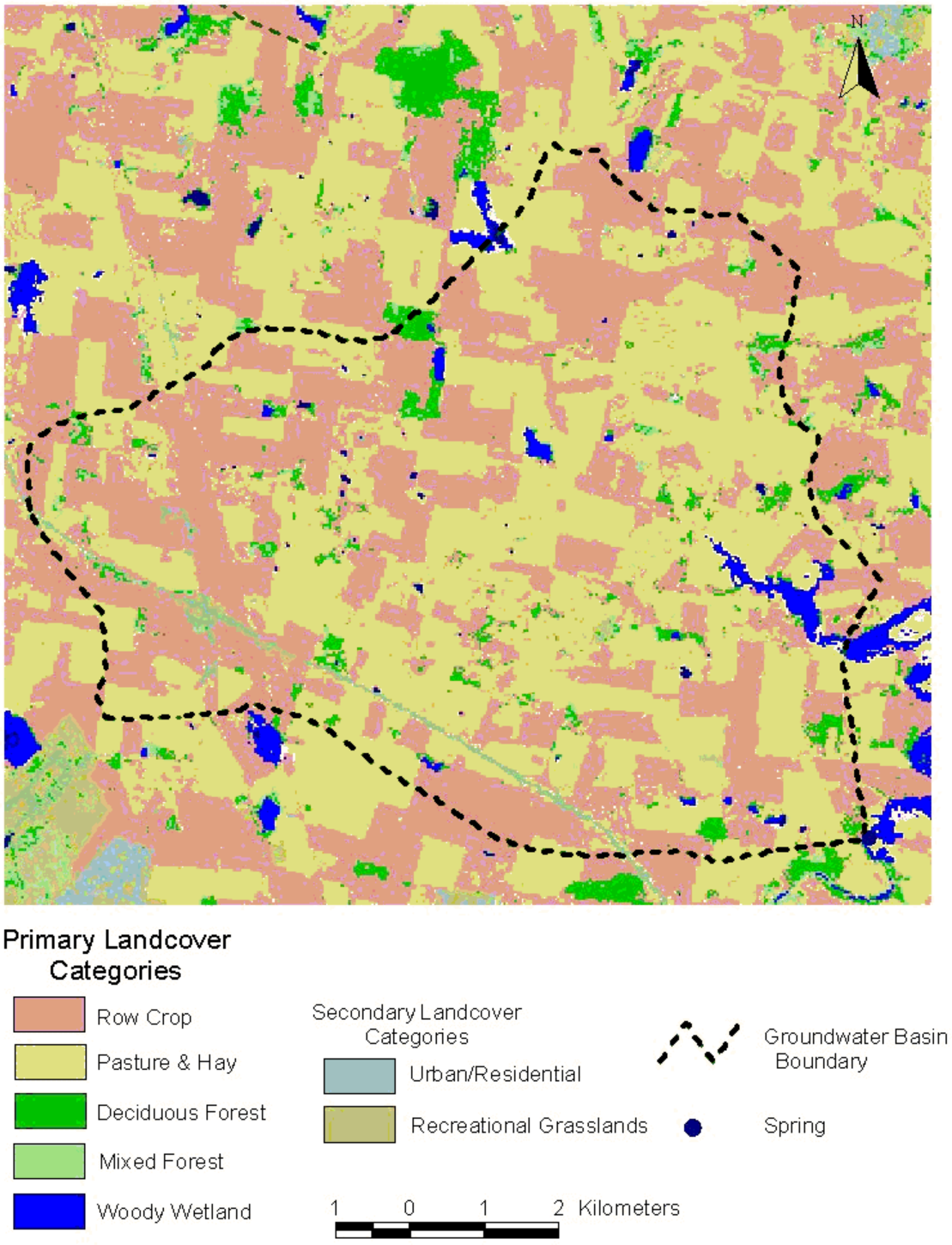

Figure 31: Barkers Mill Spring Basin Land Cover

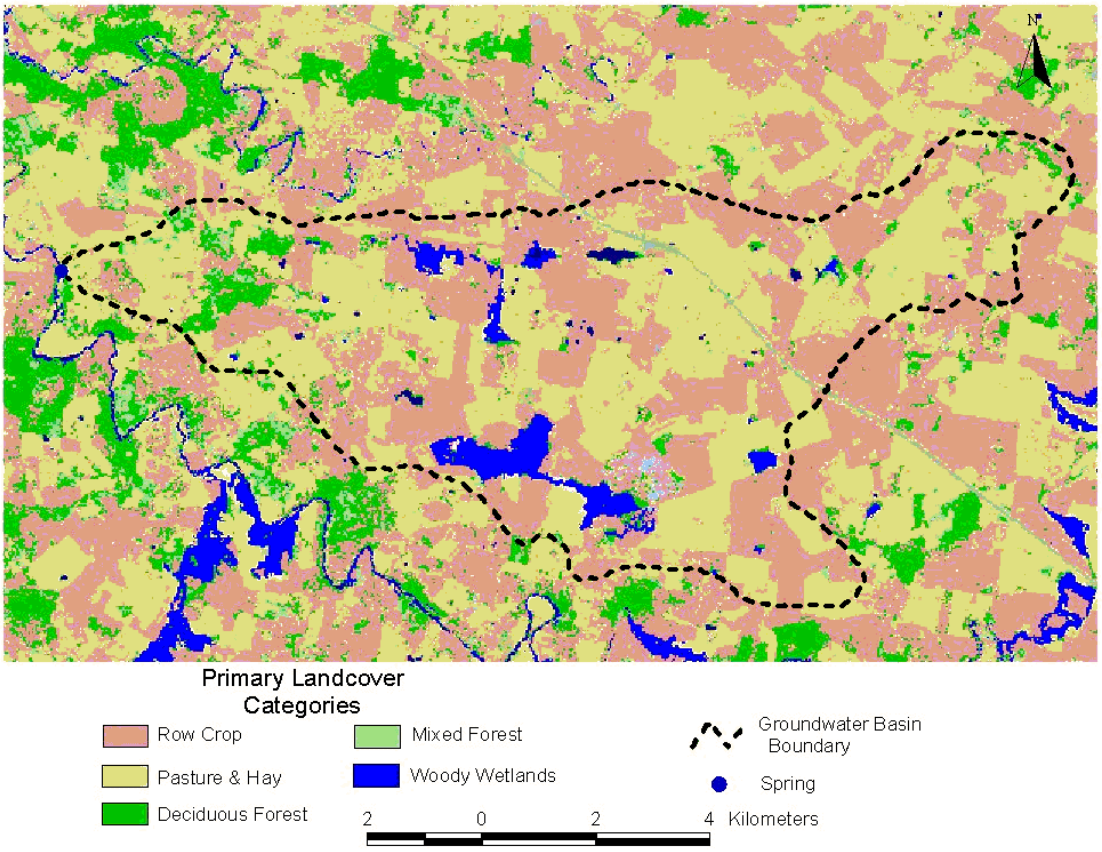

Figure 32: River Bend Spring Basin Land Cover

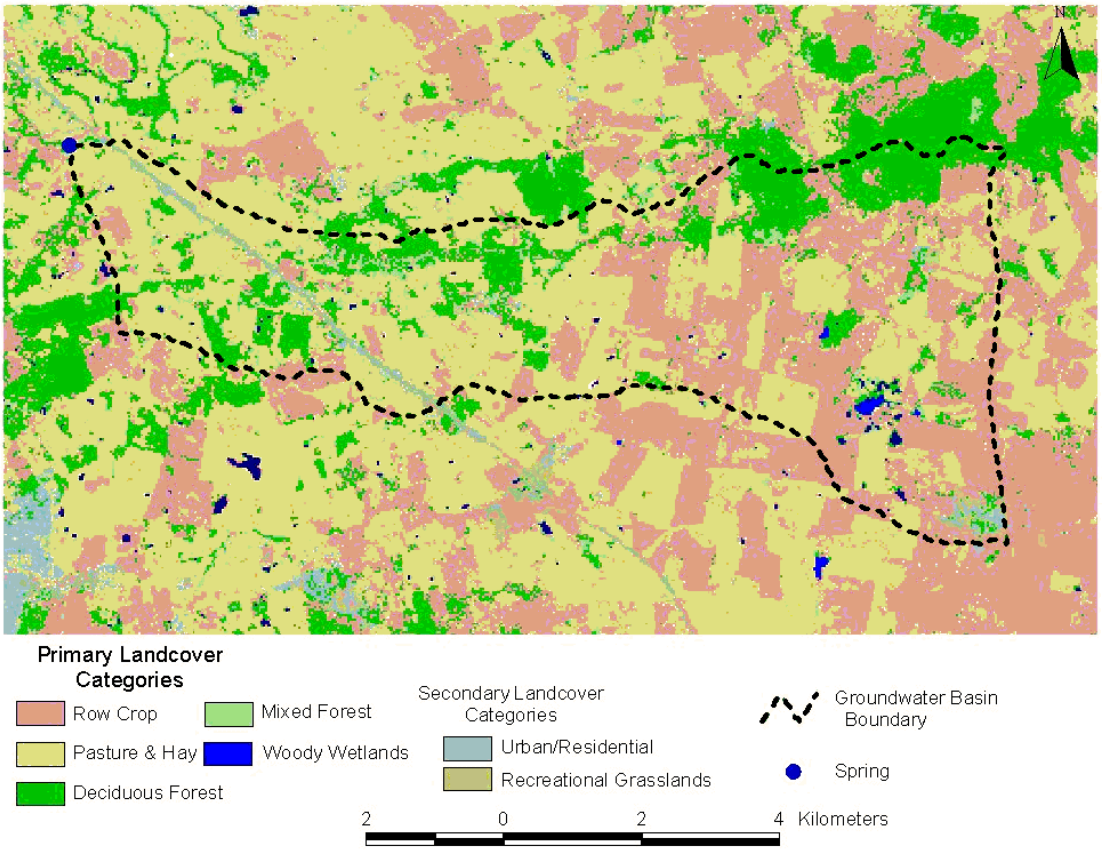

Figure 33: Cook Spring Basin Land Cover

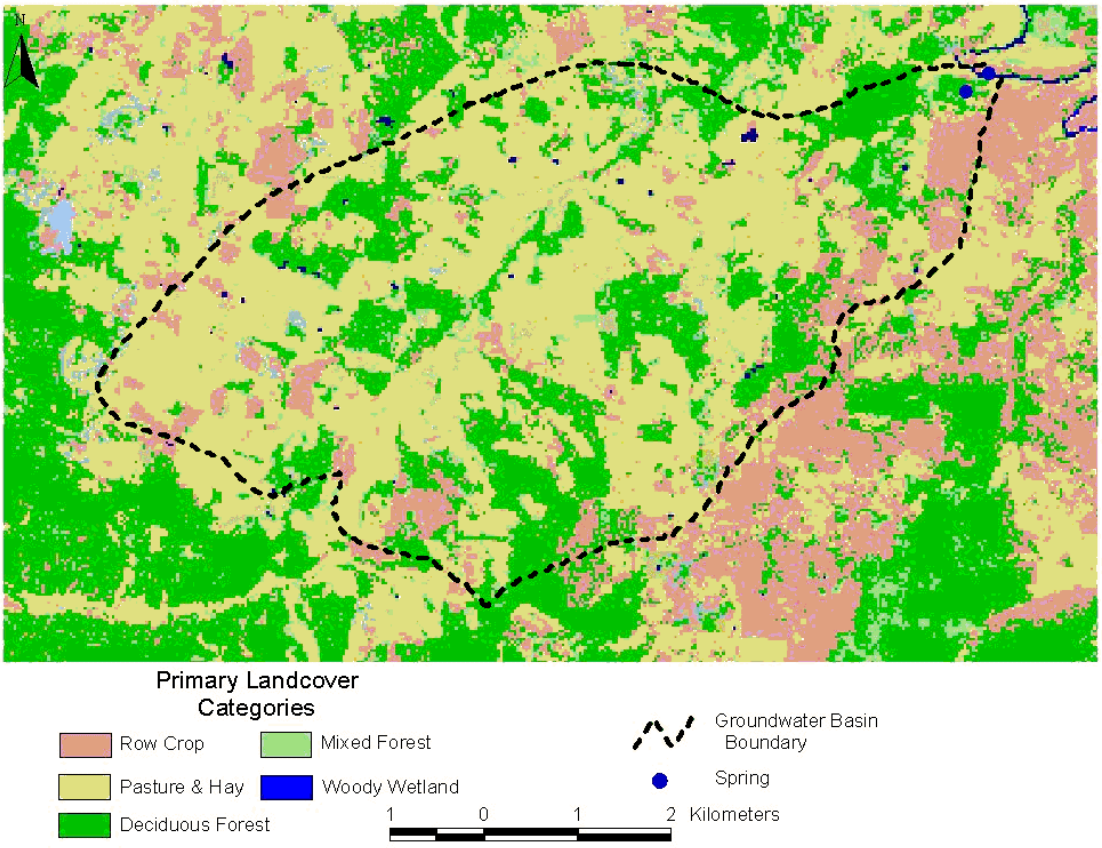

Figure 34: Brelsford Spring Basin Land Cover

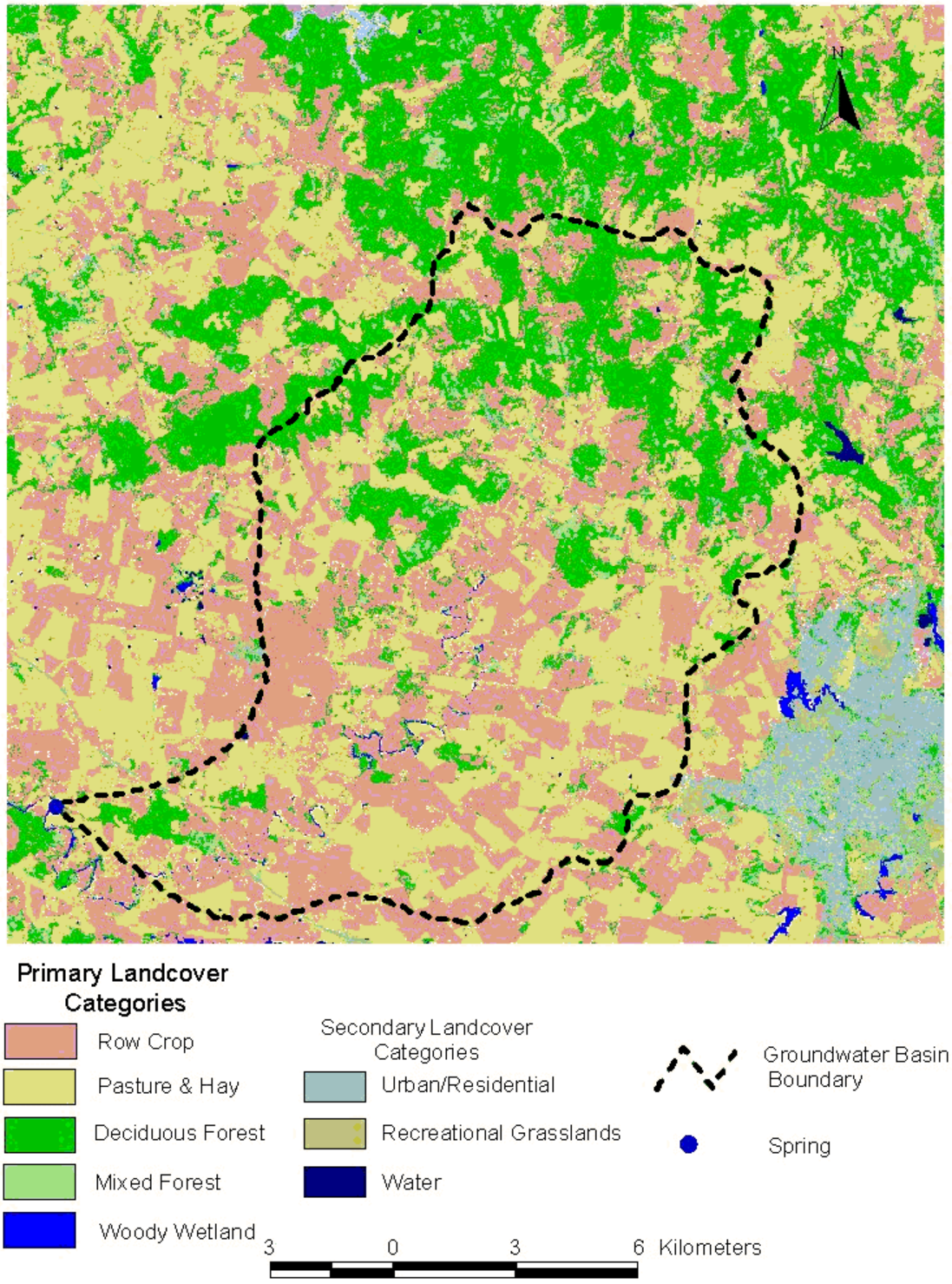

Figure 35: Mill Stream Spring Basin Land Cover

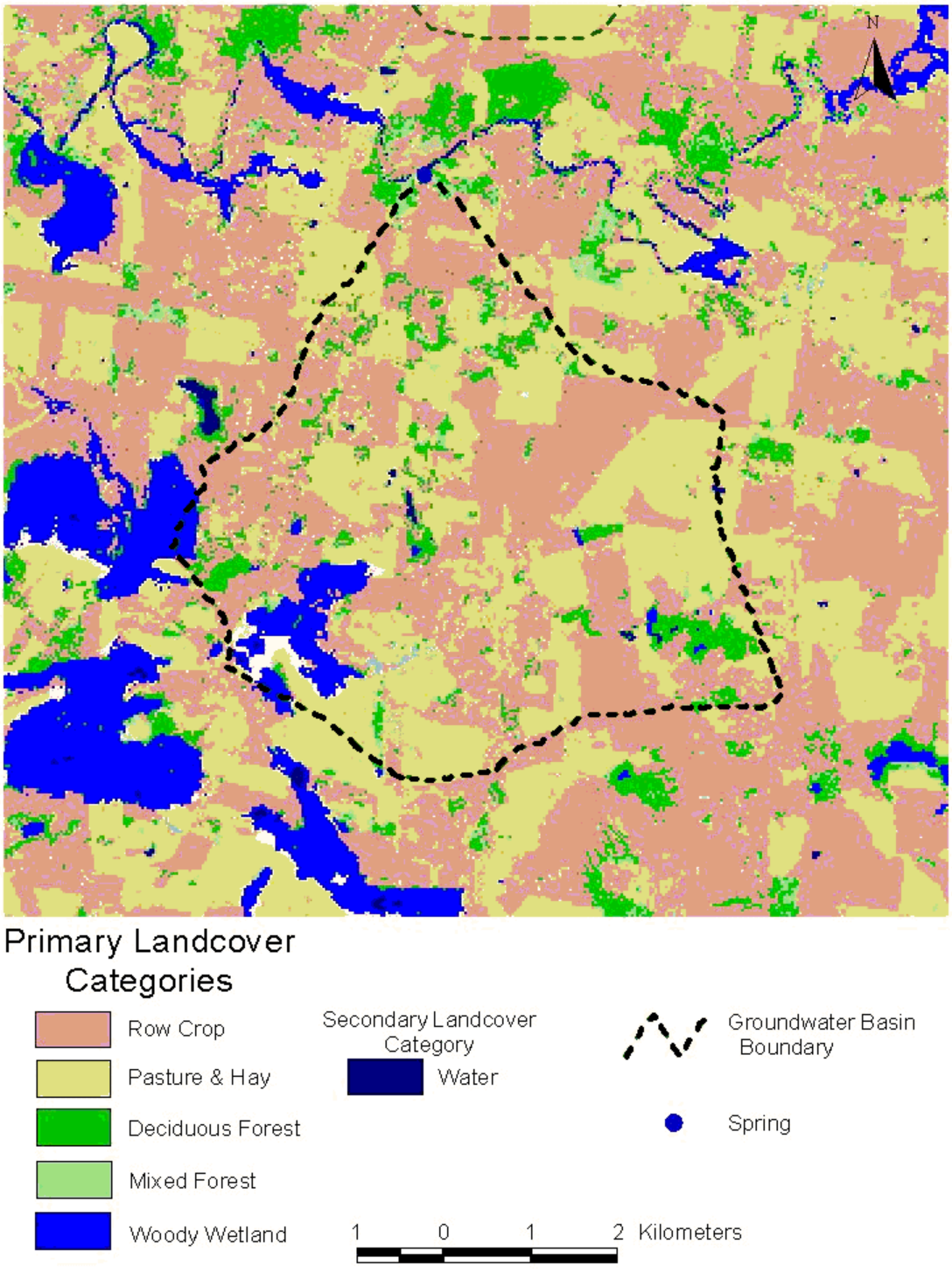

Figure 36: King Springs Basin Land Cover

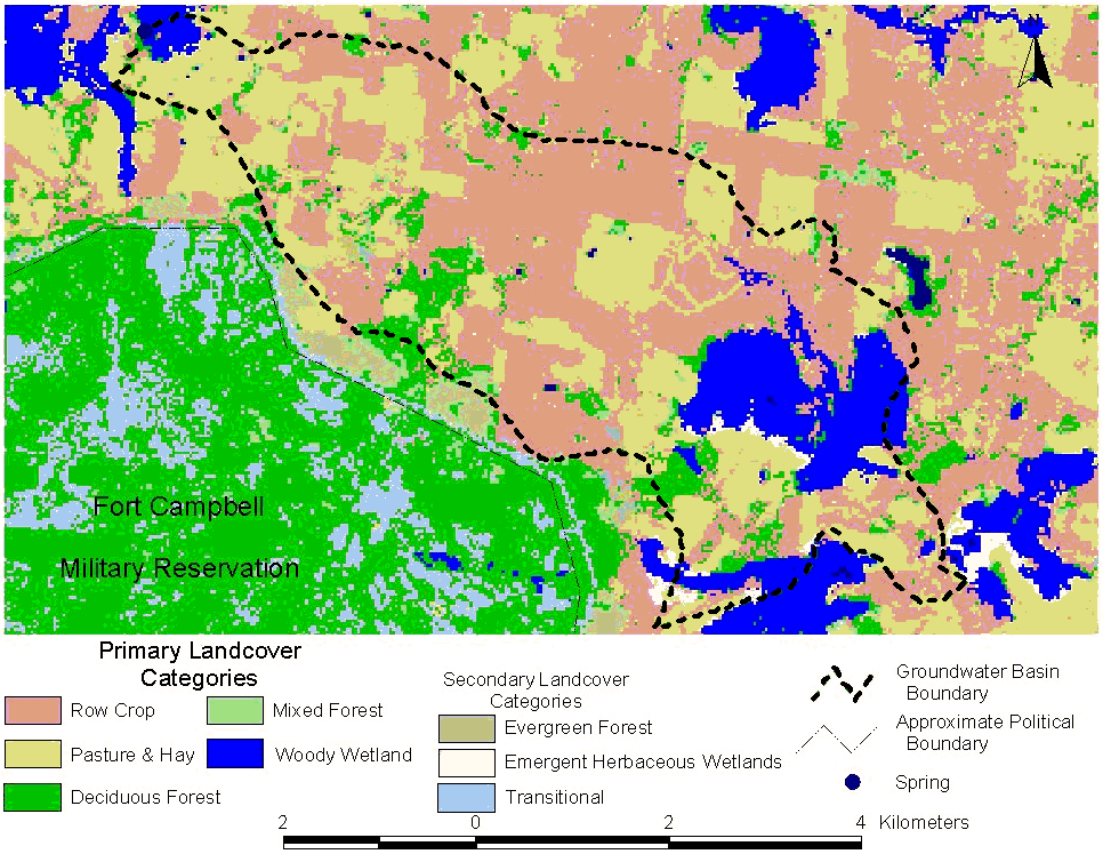

Figure 37: Walton Spring Basin Land Cover

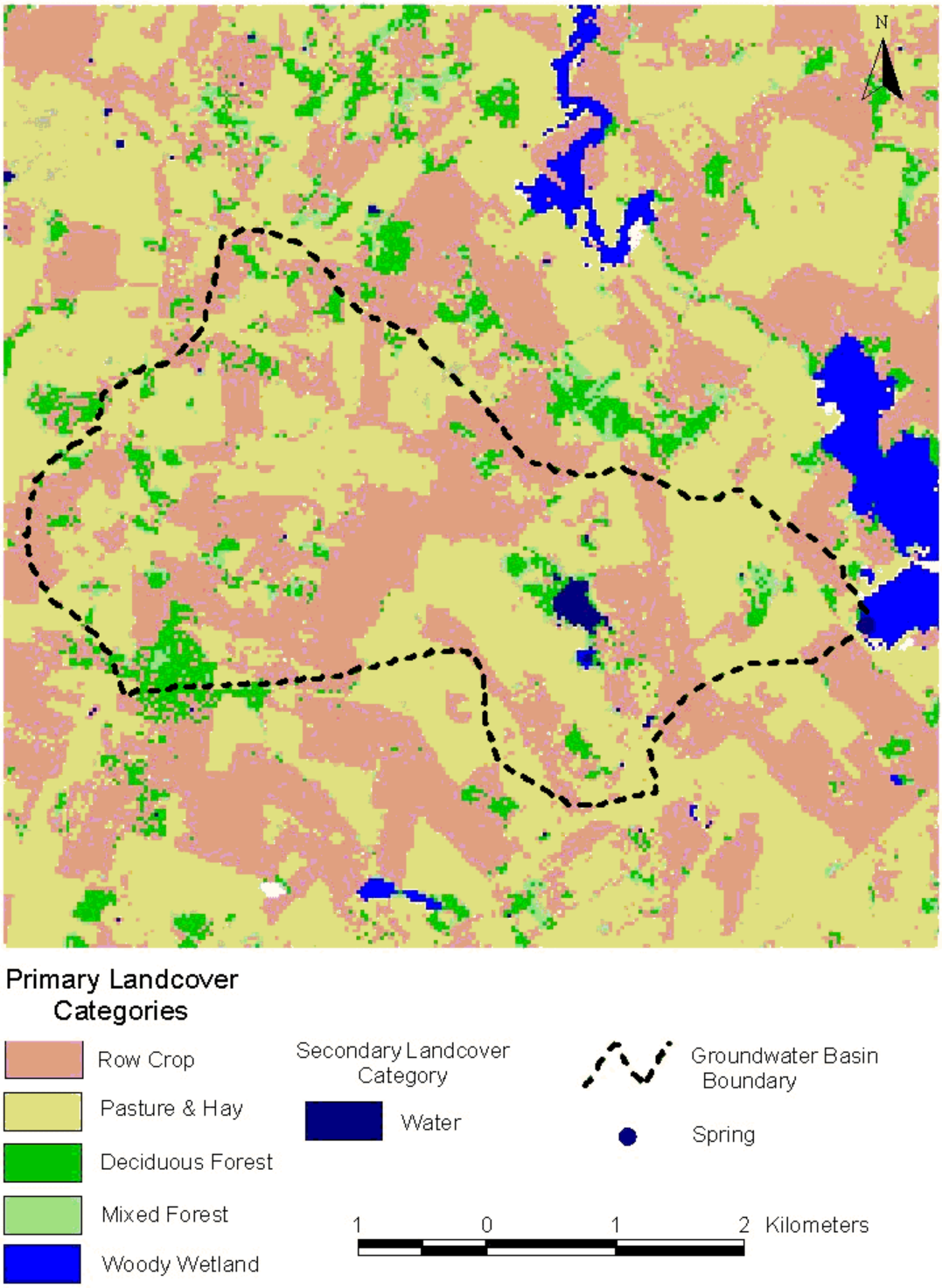

Figure 38: Wright Spring Basin Land Cover